MC13xx

High Speed CMOS Camera

MC13xx Users Manual Rev. 1.08
Camera-Firmware: V1.10-F1.31
Kamera ID Nr.: MC1302, MC1303, MC1310, MC1311

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Table of contents

1 General

1.1 For customers in the U.S.A.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. You are cautioned that any changes or modifications not expressly approved in this manual could void your authority to operate this equipment. The shielded interface cable recommended in this manual must be used with this equipment in order to comply with the limits for a computing device pursuant to Subpart J of Part 15 of FCC Rules.

1.2 For customers in Canada

This apparatus complies with the Class A limits for radio noise emissions set out in Radio Interference Regulations.

1.3 Pour utilisateurs au Canada

Cet appareil est conforme aux normes Classe A pour bruits radioélectriques, spécifiées dans le Règlement sur le brouillage radioélectrique.

1.4 Life Support Applications

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Mikrotron customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Mikrotron for any damages resulting from such improper use or sale.

1.5 Declaration of conformity

Manufacturer: **Mikrotron GmbH**

Address: Freisingerstr. 3
85386 Eching
Deutschland

Product:
camera MC1302
camera MC1303
camera MC1310
camera MC1311

The dedicated products conform to the requirements of the Council Directives 89/336/EWG for the approximation of the laws of the Member States relating to electromagnetic consistency. The following standards were consulted for the conformity testing with regard to electromagnetic consistency.

EC regulation	Description
EN 61000-6-3	Electromagnetic compatibility
EN 61000-6-1	Immunity

Eching, June 06th. 2003

Mikrotron GmbH

Dipl.-Ing. Bernhard Mindermann
President of Mikrotron

1.6 Warranty Note

Do not open the body of the camera. The warranty becomes void if the body is opened.

1.7 Remarks, Warnings

This document contains important remarks and warnings. See the corresponding symbols:

	**Important remark**

	**Attention, Warning**

2 Introduction

The CMOS high speed camera MC13xx is a high resolution camera with 1280•1024 pixel. Benefits of CMOS technology are high speed, random access to pixels with free programmability and low power.

The camera uses industry-standard C-Mount lenses. The sensor diagonal is 1,25“ with square pixels measuring 12µm.

Free programmability means that the user is free to define the region of interest by size and position and the speed of data output. The frame rate can be slected between 25 fps and several thousand fps depending on resolution and video datawidth.

With a resolution of 1280 x 1024 pixel, 500 fps (MC131x) can be output via the “full Camera Link® parameter sets are called: profiles and stored in non volatile memory.

2.1 Top level specifications

- high resolution: 1.280•1.024 pixel CMOS sensor
  with 1300 A/D converters
- up to 1.024 gray levels
- up to 100 full frames/s for MC1302/03
  up to 500 full frames/s for MC1310/11
- arbitrary region of interest
- high sensitivity
- 12µm square pixels
- electronic “Freeze Frame” shutter
- low blooming
- programmable via serial link
- patented ImageBLITZ® image trigger (MC1310/11)
- asynchronous trigger
- download customer specific FPGA preprocessing firmware
- small, compact housing
- wide power supply range

2.2 Electronic „Freeze Frame“ Shutter

Preceding exposure, the contents of all light sensitive elements is cleared. When exposure terminates, accumulated charge is transferred to an analog memory associated which each pixel. It stays there until it is read out (and discharged) by the A/D conversion cycle.

As all light sensitive elements are exposed at the same time, even fast moving objects are captured without geometric distortion.

2.3 Differences between the camera types

The CMOS cameras MC1302/10 are monochrome, the MC1303/11 are a color cameras equipped with a Bayer filter.

MC13xx is being delivered in four different versions, color / monochrome, with or without Full Camera Link® interface. As reference the phased-out MC1301 is also shown.

Features / Type	Data width (bits)	Color/ Mono	Full Camera Link®	Base Camera Link®	Framerate@ 1280 x 1024	Image-BLITZ®	Housing depth mm
MC1301	8	M	-	+	100fps	+	55
MC1302	10	M	-	+	100fps	-	48
MC1303	10	C	-	+	100fps	-	48
MC1310	10	M	+	+	500fps	+	48
MC1311	10	C	+	+	500fps	+	48

Table 2.3-1

2.4 Using the camera

There are no serviceable parts inside the camera.. The camera may not be opened, otherwise guarantee is lost.

Use dry, soft lens-cleaning tissue for cleaning lenses and, if necessary, the sensors window.

3 Hardware

3.1 Camera Link® Interface

Camera Link® is designed for digital cameras in machine vision applications. A “Full Camera Link®” interface can transfer up to 64 bits of data at a rate of >528 Mbytes/sec.

3.1.1 Serial interface

The communication via the serial interface is incorporated in the “Base Camera Link® interface. A description of the connector pinning is in chapter 9.2.

3.2 Power supply

The camera needs a DC supply voltage between 8 … 35 V at a power consumption of 6,0 Watt max..

See also Connector pinning .

3.3 Status LED

A dual colour LED on the camera backplane shows the operating condition of the MC13xx.

LED orange...	The MC13xx is configuring the internal FPGA. No other activity is possible.
LED green...	The MC13xx is fully operational.
LED off...	If LED is off, despite the camera is powered, the FPGA configuration data is reloaded via the serial interface and stored in internal EEPROM. No other activity is possible.

4 Getting started

Before starting to operate the camera, make sure that the following equipment is available:

- Camera MC13xx
- C-Mount Lens
- Mikrotron Support CD
- Image processing system, e.g.: PC, frame grabber and Software

ⓘ	The frame grabber must have a Base- or Full Camera Link® Interface.

Additional items:

- 1 or 2 standard Camera Link® cables
- 1 Power supply 12VDC, 0.5A min
- 1 power cable

ⓘ	To specify cables see chapter Connector pinning.

4.1 First steps

1. Switch off the image processing system
2. Connect Camera Link® cable between camera and frame grabber.
3. Connect power cable.
4. Unscrew dust protection cover, screw in lens.
5. Switch on the image processing system and camera power supply

5 Initial setup

The MC13xx is delivered with initial parameters and therefore does not need to be configured via the serial link.

5.1 Serial number and firmware revision

Serial number and firmware revision is provided in MC13xx non volatile memory. Use **:v** command (Read serial number and firmware revision) to read serial number and firmware revision. The serial number is also marked on the type plate of the camera.

5.2 PowerUpProfile

The PowerUpProfile is the contents of all camera registers to be loaded from non-volatile memory after power up.

5.3 Camera Profile

The actual set of parameters is called Camera Profile. All changes of parameters by the serial link is reflected in the Camera Profile. On command the Camera Profile is saved to 8 user profiles or one PowerUpProfile. It is loaded from 8 user profiles or 8 factory profiles or the PowerUpProfile. The camera profile is volatile and must be stored to the PowerUpProfile to be reactivated on next poer up.

5.4 Factory profile

The factory profile can be read but not written by the user.

5.5 User profiles

The user can store up to eight PowerUpProfiles in non volatile memory. All load or write commands exchange data between the PowerUpProfile and one of the four user profiles.

Profil-Nr.	Video data width	resolution / Pixel	Image frequency /fps
0	2x8	100 x 100	4.852
1	2x8	240 x 240	1.011
2	2x8	640 x 480	202
3	2x8	1280 x 1024	47
4	2x10	640 x 480	150
5	2x10	1280 x 1024	33
6	8x8	1280 x 1024	120
7	8x8	640 x 480	954

Table 5-1

6 Configuration

The MC13xx has 15 FPGA registers, r1..rf_h , each 10 bit wide, eight D/A registers, a1..a8, 8-bit wide, and one clock select register, 4 bit wide. The contents of all the above registers is called a profile. There is space in non volatile memory for 17 profiles: one PowerUpProfile, 8 user profiles and 8 factory profiles.

Any change of a specific register through the serial interface is immediately processed and written to the volatile part of the memory and gets lost when power goes down. A command must be used to store the actual setting in non volatile memory. After power-up the PowerUpProfile is loaded from the non-volatile to the volatile part of the memory.

A load or write command exchanges data between the PowerUpProfile and one of the eight user profiles. The eight factory profiles can be read but not be written by any command. All values are given in hexadecimal notation, e.g.: 0xff or 0ffh = 255.

6.1 Commands

ASCII strings are used to change camera parameters. All commands start with a colon, followed by one selection character and a value in hexadecimal notation with two or three ASCII characters.

After a command has been recognized, processing is immediate, for all commands but the save type commands (:px). These need a EEPROM write time of app 1ms. An answer is provided with read type commans (:v, :w, :W) or, if the command “command acknowledge flag” is set, after processing of each command an ACK or NAK character. Processing of wrong command is stopped immediately on recognizing the error. A new command must start with a colon.

6.1.1 Table of commands

Syntax	Range	Answer	Description
:a<n><xx>	<n> = 1...8 <xx> = 0...ff$_h$	--	Set one of eight analog voltages for the sensor
:A<n>	<n> = „y“,“Y“,“n“,“N“		En- or disable a command acknowledge or not acknowledge (ACK or NAK)
:b<n>	<n> = 0...4	--	Select baud rate: 0=9600 Bd (default setting), 1=19.2 kBd, 2=38.4 kBd, 3=56.8 kBd, 4=115.2 kBd
:c	--	--	RESET and new Initialization of the camera, new load of PowerUpProfile. Duration: some seconds
:e...	--	--	Transmit & save a new FPGA configuration
:f<n>	<n> = 0...7	--	Reload one of eight, factory defined and calibrated profiles to PowerUpProfile.
:g<n>	<n> = 0...7	--	Reload one of eight user profiles to PowerUpProfile
:p<n>	<n> = 0...7	--	Save PowerUpProfile to one of eight user profiles, allow app. 1ms save time.
:r<n>	<n> = 1...f$_h$	--	Write a FPGA - register
:s<n>	<n> = 0…f$_h$	--	Select sensor and pixel clock from a table with 16 entries.
:S	6 Byte Code	--	Program sensor and pixel clock directly.
:t<n><m>	<n> = 00..7f$_h$ <m> = 00..ff$_h$	--	Short setting of X- position in units of 10 pixel and Y-position in units of 4 lines.
:x<xxyy>	<xx> = 0…7f$_h$ <yy> =1…80 (hex)	--	Short setting of horizontal image size and position (xx = horizontal position, yy = horizontal width (unit: 10 pixel))
:y<xxxyyy>	<xxx>=0..3ff$_h$ <yyy>=1..3ff$_h$	--	Short setting of Image size and position in Y – direction xxx = Y-position, yyy= vertical width (unit: 1 line)
:v	--	#12345-V1.10-F1.29	Read serial number (#), microcontroller - version (V...) and FPGA - version (F...).
:w	--	camera profile: 44 bytes in hex	Read actual PowerUpProfile, data output in hex
:W	--	Camera profile: 44 bytes in ASCII	Read actual PowerUpProfile, data output in ASCII

6.2 Read serial number and firmware revision

The serial number and the firmware revision can be read with the **:v** command.

Command: **:v**

Response(e.g.): #01234-V1.10-F1.29↵

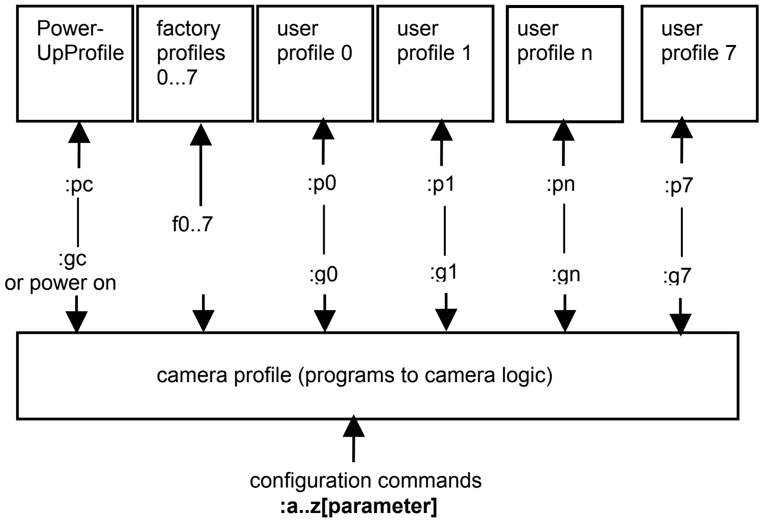
Serial number of the camera

firmware version

CR+LF (carriage return + line feed)

6.3 Profile processing

All camera settings are loaded or stored as complete data blocks (= Profiles). There are 17 profiles, the Camera profile, the PowerUpProfile, eight factory profiles and eight user profiles.



6.3.1 Read Camera profile

The response to the read Camera profile command **:w** is a hex string of the contents of all actual camera registers.

Command: **:w**
Response(e.g.): 6d774ac800006a1c61e88c41898c0003ff3ff
000080030000000000000000000000000000000000000
all values hex, e.g.: $70_{HEX} = 112_{DEC}$

Sequence of transmitted data bytes:
A1 A2 A3 A4 A5 A6 A7 A8 Sa1 Sa2 Sa3 Sb1 Sb2 Sb3 R1h R1l ... R15h R15l ↲

A1...A8	image level control (FPN, contrast…)
Sa1 Sa2 Sa3	3 Byte synthesizer code of pixel clock
Sb1 Sb2 Sb3	3 synthesizer code of sensor clock (see chapter 6.7.1)
R1…R15	image control (image position, size, sync….)
R1h ...	high Byte R1
R1l ...	low Byte R1
↲ ...	CR+LF (0dh + 0ah)

6.3.2 Write user profile

The PowerUpProfile is transferred to one of the eight user profiles.

Command: **:p<*n*>** <*n*> = 0 ... 7,c

ⓘ	**Issue this command only, if the PowerUpProfile was successfully tested.**

6.3.3 Load user profile

Load one of eight user profiles to the PowerUpProfile.

Command: **:g<*n*>** <*n*> = 0 ... 7, c

6.3.4 Load factory profile

The eight factory profiles can be read but not changed by the user.

Command: **:f<*n*>** <*n*> = 0 ... 7

6.4 Video data width, Base/ Full Camera Link®

MC13xx can output video data with 2 x 8-Bit or 2 x 10-Bit via the „Base Camera Link®“ interface, or 8 x 8-Bit or 10 x 8-Bit data via the „Full Camera Link®“ interface. Use register 7 Bits 7/5 to select..

Video data width	:r7[7]	:r7[5]
2 x 8	0	0
2 x 10	0	1
8 x 8	1	0
10 x 8	1	1

Table 6.4-1

The 10 x 8 - Bit data width lowers the clock speed for a given bandwidth, and needs a compatible frame grabber. The assignment of the 10 taps to the Camera Link® ports is described in chapter:10*8-Bit Assignment.

There are no predefined profiles for 10 x 8 Bits stored in the MC1310/11. Any predefined 8 x 8-Bit profile can be used as starting point. Then change :r7 [7,5] to 1 and set Pixel Clock speed as described in: Frequencies for video data width 10*8 - Bit. This profile can then be stored as User Profile.

MC1302/03 Setting of r7[7] is ignored by the camera.
MC1310/11: After a change of r7[7], change the selected frequency. See: Table selection of clock frequencies.

6.5 Image quality

There are three D/A converter to influence image quality: FPN, Gain, and Black up. FPN, Gain and especially Black might be adjusted if sensor clock changes. All three parameters are stored in non-volatile memory as part of the selected profile.

6.5.1 FPN

The **F**ixed **P**attern **N**oise setting reduces the fixed pattern noise that is typical to CMOS sensors. This level might be changed if the sensor clock frequency is changed. For adjustment set the lens out of focus and to a medium grey level. Lower FPN until a heavy pattern appears. Then raise by a few points.

Command: **:a1<x_1x_0>** <x_1x_0> : Range, typ. 55h ... 80h

Response: none

6.5.2 Gain

This is the threshold for the A/D converters. Its standard value is 66h for app. 1V. One step is app. 10mV. To increase the gain the value of a2 must be lowered.

Command: **:a2<x_1x_0>** <x_1x_0> : Range,
typ. 30h ... 80h

6.5.3 Black Level

Change Black Level if sensor clock changes. Increase this parameter until grey values in no light condition (closed lens) are close to zero.

Command: **:a5<x_1x_0>** <x_1x_0>: Range,
typ. 00h ...ffh

Response: none

6.6 Image size and position

Image size and position within the sensor is defined by four parameters:

Bit(s)	Description
r1[9..0]	Number of first line, 0..3FD$_h$
r3[9..0]	Number of lines, 0..3FF$_h$
r4[6..0]	Address/10 of the first pixel
r5[6..0]	Address/10 of the last pixel

Table 6.6-1

6.6.1 Address of the first line

Register r1 defines the first line to be displayed.

Command: **:r1<$x_2x_1x_0$>**
<$x_2x_1x_0$> ... Range 000h ...3fdh
Response: none
Example: :r1100
100h = image starts at line 257

ⓘ	If dual column binning is activated, r1 is doubled within the camera logic.

6.6.2 Number of lines

Register r3 defines the number of lines to output.

Command: **:r3<$x_2x_1x_0$>**
<$x_2x_1x_0$> ... Range 000 h ...3ffh

Response: none
Example: :r3200 200h = display 513 lines

ⓘ	The sum of r1 and r3 must be ≤ 0x3ff/1023 or 0x1ff/511 if dual column binning is activated!

6.6.3 Address of the first pixel of a line

Register r4 defines the leftmost pixel. The value is the pixel address divided by ten.

Command: **:r4<$x_2x_1x_0$>**
<$x_2x_1x_0$> ... Range 000h ...7fh
Response: none

Calculation of the value of r4:
Value of r4 = Pixel-Nr./10

6.6.4 Address of the last pixel of a line

Register r4 defines the rightmost pixel. The value is the pixeladress divided by ten.

Command: **:r5<$x_2x_1x_0$>**
<$x_2x_1x_0$> ... Range 000h ...07fh
Response: none

Calculation of the value of r5:
Value of r5 = Pixel-Nr./10

ⓘ	The difference r5 - r4 must be in the range: 0 ≤ r5-r4 ≤ 7fh .

6.6.5 Tracking

For rapid window movement even at slow baud rates a short command is provided..

command: **:t<*n*>,<*m*>**
<*m*> = X-position in pixel/10, range 00h ...07fh
<*n*> = Y-position in lines / 4, range 00h ...0ffh

Response: none

6.7 Clock selection

The MC13xx is equipped with a 2-channel programmable clock synthesizer. One channel controls clock frequency of the sensor (sensorclock, F_{sens}), the other controls the frequency of the pixel clock (pixel-clock, F_{pix}). These independent clocks allow an always optimal ratio depending on the product of (image size • image frequency) and the data rate on the output.

Example:
The MC13xx is connected to a frame grabber with a maximum data rate of 66MBytes/s via the„Base Camera Link®“ interface using
2 x 8 bit video data.. A pixel clock of 33 MHz has to be selected.

As the sensor outputs 10 pixel per clock a sensor clock of 6.6MHz could be chosen. Because the sensor can run up to a clock frequency of 66 MHz only 1/10 of the sensors possible speed would be used. To make use of the maximum sensor clock and maintaining the maximum data rate on the output, just 120 (1280/10 rounded to steps of 10) from the possible 1280 pixel per line can be selected.

Therefore the ratio of F_{sens} and F_{pix} depends on the selected line length:

$F_{sens} <= (F_{pix} \bullet 1280) / (5 * \text{line length})$

or if 100 pixel line length is chosen:
$F_{sens} = (33 \bullet 1280) / (5 \bullet 100) = 70{,}4$ MHz

As this exceeds the maximum sensor clock frequency, F_{sens} is chosen as 66 MHz and F_{pix} as 33 MHz.

6.7.1 Arbitrary selection of sensor and pixel clock

Sensor and pixel clock can be set to any value, the product of: (sensor clock • line length/1280) must always be smaller (about 10%) than the qoutient: (pixel clock / video data width, e.g.: 2, or 8).

If video data width of 10 x 8-Bit is selected, sensor clock = pixel clock.

command **:S** $\mathbf{<x_0>}$
$<x_0>$ ... 6 characters, as described in chapter Frequency selection

6.7.2 Table selection of clock frequencies

To simplify clock selection when using video data width of 2, clocks can be selected from a table with 15 entries, each entry being optimized for four regions of line length. (see table in 9.3).

Example: 240 < line length <= 640 Pixel, clock selection s9
pixelclock: 27,5 MHz
sensorclock: 11,2 MHz
resulting max. datarate on the 16-Bit output:
27,5 MHz/s * 2 Byte = 55,0 Mbyte/sec.

This is valid for a line length between 250 and 640 pixel.

command **:s** $<x_0>$

$<x_0>$ ... range 0 ... f (hex)

	Before selecting the data rate of the camera check the maximum data rate of the frame grabber, which must be higher (or at least the same).

6.8 Exposure control

Exposure control is selected with register r6[7..4] and register r2[9..0].

Bit(s)	Description
r6[7..4]	Type of exposure
r2[9..0]	Exposure time

table 6-1

6.8.1 Type of exposure

The MC13xx can expose the images synchronous or asynchronous.
Synchronous means that the next image is exposed, while the current image is output.
With asynchronous exposure, an external signal starts exposre, and the exposed image is output after the exposure ends. Exposure time is defined either by an internal timer or by the width of the external EXP – signal. Bits 7..4 of registers r6 define exposure type: (**:r6[7..4]**).

r6 Bits	7	6	5	4
Camera stop	x	x	x	0
Synchronous	0	0	0	1
Synchronous, with electr. shutter	0	0	1	1
Asynchronous, pulse width	1	0	1	1
Asynchronous, timer	1	1	1	1

Table 6.8-1

6.8.2 Frame rate with synchronous exposure

The frame rate with synchronous exposure is direct proportional to the selected number of lines.

The time for one line is::

$$T_{zz} = 1/F_{sens} \bullet 136 \quad [sec]$$

T_{zz} ...time/line
F_{sens}... Sensorclock

Frame rate: $= 1 / (\text{time/line} \bullet \text{number of lines}+1)$ or:
$= F_{sens} / (136 \bullet (r3[9..0] + 2))$

Dependencies between image size and frame rate for typical clock frequencies are given in the following table:

image size	100x100	240x240	640x480	1280x1024
Senso rclock (MHz)	66	33	13,2	6,6
Time/line [µs]	2,06	4,12	10,3	20,6
Frames/s	4.852	1.011	202	47

Table 6.8-2

6.8.3 Synchronous operation without shutter

Without electronic shutter the exposure time is 1 / frame rate.

6.8.4 Synchronous operation with shutter

In the sensor is implemented a freeze frame shutter, which allows to reduce the exposure time in steps of one line. The minimum value of the exposure time is the duration of 2 line periods, which is determined by the value of r2 (min. 001h).

Command: **:r2<$x_2x_1x_0$>**
<$x_2x_1x_0$> ... Range 001h ...3ffh
Response: none

Exposure time T_B :

$Tt_B = r2 \bullet T_{ZZ} - T_{ZZ} / 2$

T_B ... exposure time in s
r2 ... value of register 2
T_{ZZ} ... time/line
$T_{zz} = 1/F_{sens} * 136$ [s]
Tt_{zz} ... Time/line
F_{sens}... sensor clock

Typical exposure times:

Sensor clock frequency (MHz)	Zeit/Zeile (µsec)	r2 bei 1/5.000 s	r2 bei 1/10.000 s
66	2,06	97	49
33	4,12	49	24
13,2	10,3	19	10
6,6	20,6	10	5

Table 6.8-3

6.8.5 Frame rate with asynchronous exposure

The frame rate with asynchronous exposure = Frame rate with synchronous exposure – (1 / exposure time).

6.8.6 Asynchronous exposure, shutter control by pulse width

This operating mode is selected with register 6:
:r6[7..4] = 0xb

Exposure time depends on the width of the external EXP – signal.

6.8.7 Asynchronous exposure, shutter control by timer

This operating mode is selected with register 6:
:r6[7..4] = 0xf

The asynchronous exposure time is dependent on :r2[9..0]. The exposure timer counts as many lines as are defined in register :r2[9..0].

Exposure time:

$T_B = 1/F_{sens} * 136 \bullet (1+r2[9..0])$ [Sec]

T_B ... exposure time

F_{sens}.. sensor clock

example: sensor clock = 66MHz

value of r2[9..0] = 6

$T_B = 136 \bullet 6 \bullet 15$ ns = 12,2 µs

6.9 Firmware

6.9.1 Update Firmware

MC13xx's logic is integrated into a FPGA (**F**ield **P**rogrammable **G**ate **A**rray), which's configuration is stored in an EEPROM. Upon power up or a command the FPGA is loaded with this configuration. Configuration data can be downloaded via the serial interface of Camera Link®. Mikrotron may provide configuration files (*.ibf) on request.

After download of configuration data, this data is permanently stored in EEPROM and the FPGA is configured with the new data. Besides a power cycle, the **:c** command can be used to reconfigure the FPGA with the internally stored configuration data.

> **Download of *.ibf file via serial link with 9600Bd takes app. 1.5 min. There should be no loss of power or communication during this time!**

6.9.2 Reset and configuration of the internal FPGA

The command **:c** executes a reset in the camera. The FPGA will be reconfigured and all internal registers reloaded with the last saved PowerUpProfile. The FPGA is also configured after each power up.

Command: **:c**
Response: none

6.10 Horizontal pixelbinning

Pixelbinning adds the gray values of two adjacent pixels and outputs it as one pixel with double sensitivity. In X-direction only 512 pixels are needed to cover the sensors full size. To retain aspect ratio, every second line is omitted or vertical pixelbinning can be activated.

Command: **:r7010**
Response: none

When selecting lines with $\mathbf{r_1}$, or $\mathbf{r_3}$ the contents of r1 is doubled in camera logic. To address a specific line on the sensor, the value of r1 has to be divided by two and r3 must not exceed 1ffh.

Example:
To output 256 lines from line 128, set r1 = 63 and r3 = 255 (=0xff).

6.11 Vertical pixelbinning

Vertical pixelbinning adds the gray values of two superimposed pixel of a column. This doubles sensitivity and vertical field of view. To retain aspect ratio, in addition horizontal binning must be activated. To activate, set bit 2 in register 6.

Command example: **:r6034**
Response: none

6.12 Digital shading correction

For the best possible image quality even at the sensors clock limit, and non uniform lighting, the MC13xx can store gray levels along one line and subtract these from all lines of an image.

To setup shading correction set:
:r6[1] = 0.

Then a uniform object should be used together with the desired lighting, exposure mode and time and lens. The lens should be closed so that the remaining light level along the center line of the image is as close to zero as possible, but not reaching zero.

Then set
:r6[1] = 1.

The gray levels along the center line of the image are saved in volatile memory and then subtracted form all lines of the following images, as long as this bit remains set.

6.13 Digital gain

Digital gain selection is only possible with video data width 2 x 8-Bit or 8 x 8-Bit. Out of the 10-bits sensor data either the most significant 8 bits (gain 1), or bits 8..1 (gain 2), or the least significant 8 bits (gain 4) are selected.

Command: **:r700x**
x = 0: gain 1
x = 4: gain 2
x = 8: gain 4

6.14 External clock input

MC13xx frequency synthesizer can use the Camera Link® used to synchronize several MC13xx to one master clock.

To activate set Bit 9 of register 7.

Command example: **:r7200**
response: none

If the external reference clock is different from 3.6864 MHz, the codes for the clock synthesizer have to be recalculated.

6.15 Polarity of EXP-signal

The polarity of the EXP-signal can be positive- or negative active.
Use :r7[8] to select.

Negativ = :r7[8] = 1

Positiv = :r7[8] = 0

Command example: **:r7100**
Response: none

6.16 Test image

For testing of camera logic and video data transmission, sensor data can be replaced by an internal gray scale pattern with pixel values of 0..127. Use digital gain command to see pixel values of 0..255.

Command example: **:r7040** r7[6]
Response: none

6.17 Image counter

If a sequence of frames is to be recorded for long time at a high frame rate, it can be useful to mark the images for later identification or check for completeness.
MC13xx has a 16-Bit image counter whose count can replace the first two pixel of every image. The image counter is cleared with every low to high transition of r7[1], the camera enable bit. It is incremented by every new image.

Command example: **:r7002** r7[1]
Response: none

6.18 ImageBLITZ® shutter release, MC1310/11 only

The ImageBLITZ® shutter release is only implemented in MC1310/11, not in MC1302/03.

ImageBLITZ can replace an external signal (e.g.: a light barrier) to release the shutter. Like a light barrier, ImageBLITZ is used to capture fast moving objects on the exact same position on the image.

Contrary to the light barrier, ImageBLITZ uses the same information as condition to release the shutter as the then exposed image.

ImageBLITZ defines one specific line or a part of the 1024 lines as trigger window. This is true even if the selected image size is less 1024 lines or outside of the selected image area.

After activation of ImageBLITZ and after issuing the EXP signal as an enable signal, the MC131x hardware checks the gray values in the trigger window at a repetition rate that is defined by the exposure time selected with bits 3..0 of r6.

If a selectable number of pixels along that trigger window exceed or fall short of a selectable threshold, one single image is exposed and output.

To adjust ImageBLITZ®, the trigger line can be superimposed to the image. Within the selected line, 10 pixel are displayed as a dotted black- and white line as long as the selected threshold is not passed.

ImageBLITZ is configured with the registers r8..rC$_h$:

6.18.1 ImageBLITZ® processing

When ImageBLITZ® is activated with :r7$_h$[0] = 1:

1. Wait for an active edge on the EXP input.
2. The MC13xx exposes a line, that was chosen with :rC[9..0] and is called trigger line, for an exposure time defined by :r2[9..0]. It compares the intensity of a group of 10 pixel along the selected trigger line against an adjustable threshold (:rA$_h$[7..0], Range: 255..0).
3. The number of exceedings (:rA$_h$[8] = 0) or fall backs (:rA$_h$[8] = 1), are counted, and the result is compared to a second threshold (:rB$_h$[6..0], Range: 127..0).
4. Each time this threshold is exceeded (release condition); an “inhibit counter” (:rD$_h$[9..0], Range 1..255) is loaded.
5. The inhibit counter” :rD$_h$[9..0] is counted down, each time the “release condition” was not reached. Once this “inhibit counter” has expired, a new image is exposed and output.After image is output, repeat at 1.

6.18.2 ImageBLITZ® programming

ImageBLITZ® is programmed by registers r8..rD$_h$ and activated with r7[0].

6.18.2.1 Address of trigger line

The register rC$_h$ determines the vertical position of the trigger line in the image.

command: **:rC$_h$ $<x_2x_1x_0>$**
$<x_2x_1x_0>$ ... range 00h ...3ffh
Response: none

Example: :rc100
100h = 256

ⓘ	In pixelbinning mode the value of rC is internally doubled. The value must not be higher than 1ffh/511.

6.18.2.2 Leftmost pixel of the triggerline

The value of register r8 / 10 is the number of the leftmost pixel in the trigger line.

Command: **:r8 $\langle x_2x_1x_0 \rangle$**
$<x_2x_1x_0>$ ... range 000h ...07fh
Response: none

Calculation of r8:
Value of r8 = pixel number / 10

6.18.2.3 Rightmost pixel of the trigger line

The end of the trigger line is determined by the value of register r9.

Command: **:r9**$<x_2x_1x_0>$
$<x_2x_1x_0>$ ... range 000h ...7fh
Response: none

Calculation of r9:
Value of r9 = pixel number / 10

6.18.2.4 Threshold level, mark trigger line

The threshold level is set by register rA_h . The pixel values along the trigger line are compared with this value.

Command: **:rA_h** $<x_2x_1x_0>$
$<x_1x_0>$ ... range 0 ..ffh
$<x_2>$ = 0: pixel gray level > threshold level, trigger line not visible
1: pixel gray level < threshold level, trigger line not visible
2: pixel gray level > threshold level, trigger line visible
3: pixel gray level < threshold level, trigger line visible
Response: none

The trigger line is displayed as dashed, black and white line. One dash has a length of 10 pixel. The trigger line is only displayed in parts of the line where the pixel fulfill the trigger requirements.
Under normal operation conditions the trigger line will be visible only in parts. The number of dashes may be counted and used for the setting of register rB_h.

6.18.2.5 Release condition

Register rB_h contains the release condition.
The release condition is determined by the number of pixels along the triggerline that fulfill the trigger requirements.

Command: **:rB_h** $<x_{9..0}>$
$<x_{6..0}>$ = 0 ..7fh, number of pixel that match the trigger requirements
$<x_{8..7}$ = 0: correction value 0 for the X - position of output window
$<x_{8..7}$ = 1: correction value 4 for the X - position of output window
$<x_{8..7}$ = 2: correction value 8 for the X - position of output window
$<x_{8..7}$ = 3: correction value 12 for the X - position of output window

Response: none

6.18.2.6 Release Inhibit

The Release Inhibit function is defined with :rD_h. It tells ImageBLITZ how often sequentially the "release condition" must **not** be met, before an image is output.

This feature allows to trigger an object only once on the dark- to bright edge of the scene. This avoids retriggering, once the trigger condition was met and the object is still visible within the triggerline after the image has been output.

Command: **:rD$_h$ $<x_{7..0}>$**
$<x_{7..0}>$ = 0 ..ffh, number of fulfilled,
sequentially trigger conditions

Response: none

6.18.3 ImageBLITZ® registers

Register	Bit	Description
r7	0	= 1: activate ImageBLITZ®
r8	6..0	First pixel mod. 10
r9	6..0	Last pixel mod. 10
rA$_h$	7..0 8 9	Exposure threshold 1: bright object triggers 0: dark object triggers 1: make triggerline visible
rB$_h$	6..0 8..7 9	Number of exceedings or fall backs, release condition, X – tracking correction X – tracking enable.
rC$_h$	9..0	Address of triggerline
rD$_h$	7..0	exposure limitation, number of exposures without exposure condition until an image is captured

Table 6.18-1

Registers r1..r7 are programmed according to image size and position and for Asynchronous operation, timer .

Register	Bit	Description
r1, r3..r5		Image size and position
r2 r6	9..0 7..4	Async operation, timer 0fh

Table 6.18-2

6.18.4 ImageBLITZ® setup

The MC13xx is configured for asynchronous operation with timer , registers r8, r9 and rC_h are loaded for the desired position of the trigger line. Register rB_h is loaded with 0, register rA_h with 201_h, so that the trigger line is visible.

ⓘ	If the image is zoomed down for display by an application program, every other line may be omitted and the trigger line may then disappear.

ImageBLITZ® is enabled with Register r7 Bit1=1.

Now position the trigger line with the registers r8, r9 and rC_h across the object that is used for the shutter release..

Clear Bit 8 in Register rA_h if a bright objects releases the shutter, set rA_h[8] if dark objects release the shutter. While the trigger line is placed across the object, raise threshold with rA_h[7..0] until as many dashes from the trigger line disappear as are loaded in Register rB_h [6..0]. This is called the release condition.

If it is expected that the release condition is met more than once for a single object, load rB_h [9..7] with a number of exposed lines that will not met the release condition before exposing one image.

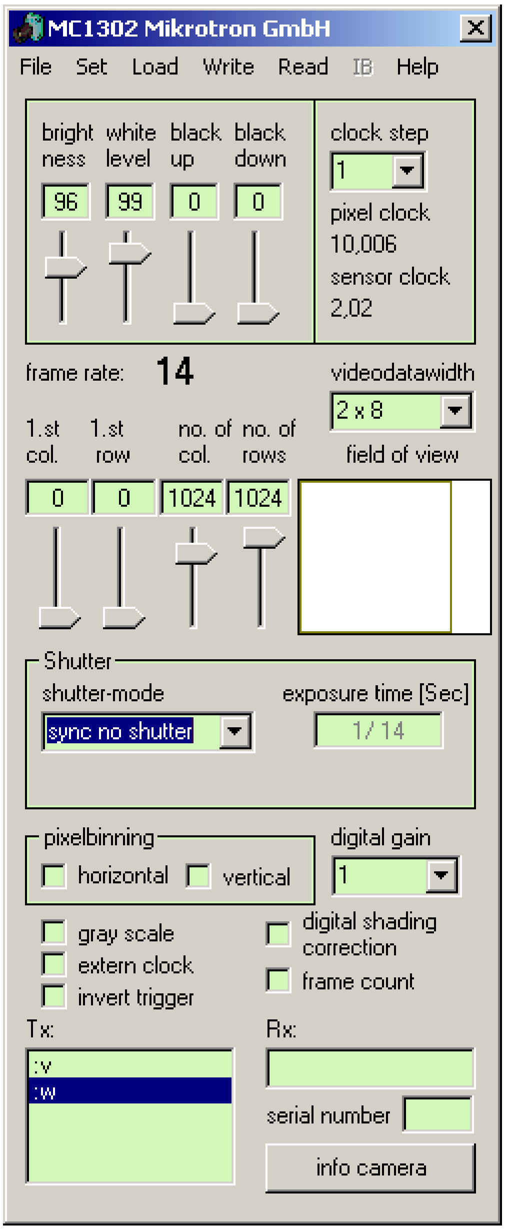
7 MC13xx configuration tool

The MC13xx configuration tool must be installed on a Windows PC. (Win9x, WinNT, Win2K, WinXP) by means of the setup software. See also www.mikrotron.de to download the latest version.

This software provides an almost self explaining user interface to modify any camera parameter. The description of the parameters follows the marked chapters in this user manual.

To use this tool with the camera MC13xx the serial interface is integrated in the Camera Link® interface. You do not need any other additional cable.

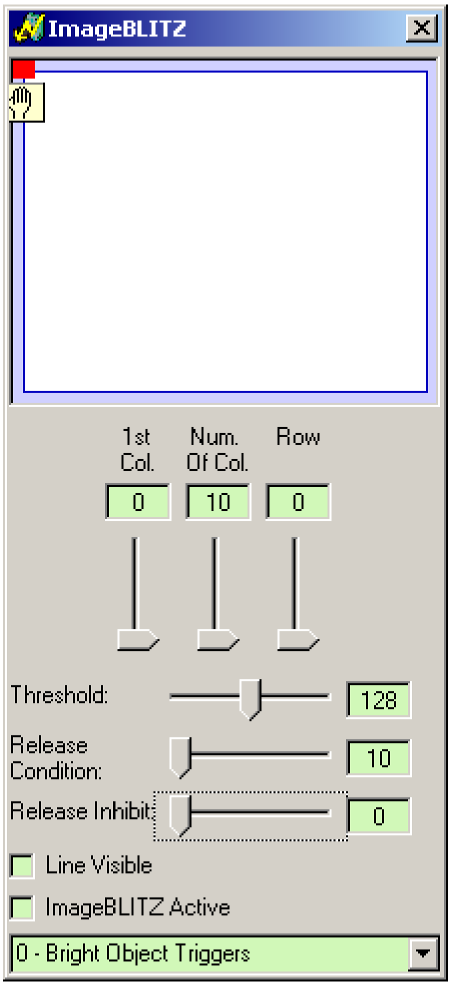
7.1 Basic Configuration



File: Save or read settings to or from file.
Set: Select com port. If Inspecta-4D and the correct cable is used, the MC13xx can be written to but not being read from.
Load, Write, Read: Profile processing
FPN, Gain …:
Adjusting image
Clock Step:
Clock selection
1.st col…num. of rows:
Adjusting Image
Shutter:
Type of exposure
Frame count (6.17),
gray scale (6.16),
invert trigger (6.15),
extern clock (6.14),
digital gain (6.13)
pixelbinning……(6.10)

Info camera:
Read serial number and firmware version
Tx:
Display control strings
Rx:
Display response

7.2 ImageBLITZ® Configuration



1st Col, Num Of Col., Row (Position of TriggerLine):
r8, r9 and rC

Threshold:
rA

Release Condition:
rB

Release Inhibit:
rD

Line Visible:
rA Bit 8

ImageBLITZ Active:
r7 Bit 0

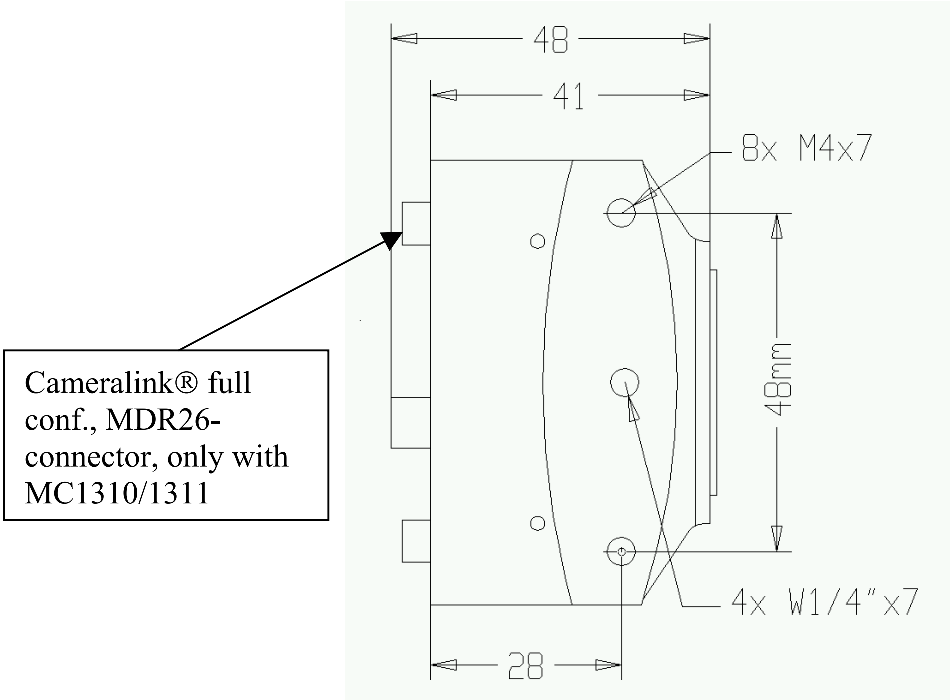
Bright Object Triggers:
rA Bit 9

8 Mechanical dimensions

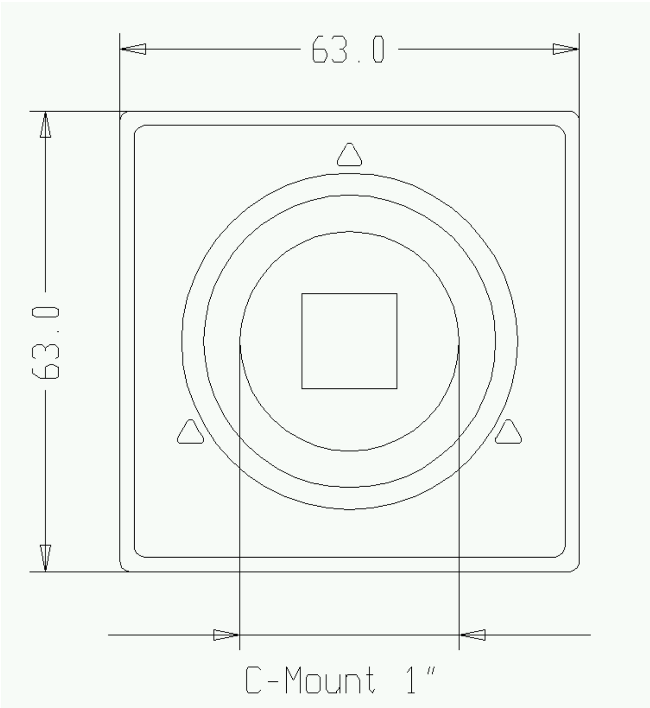
8.1 Camera body

The camera body is with its dimensions of 63 x 63 x 41 mm (without lens) very compact. To fasten the camera there are two mounting holes M4x7mm and one tripod connection on each side available.

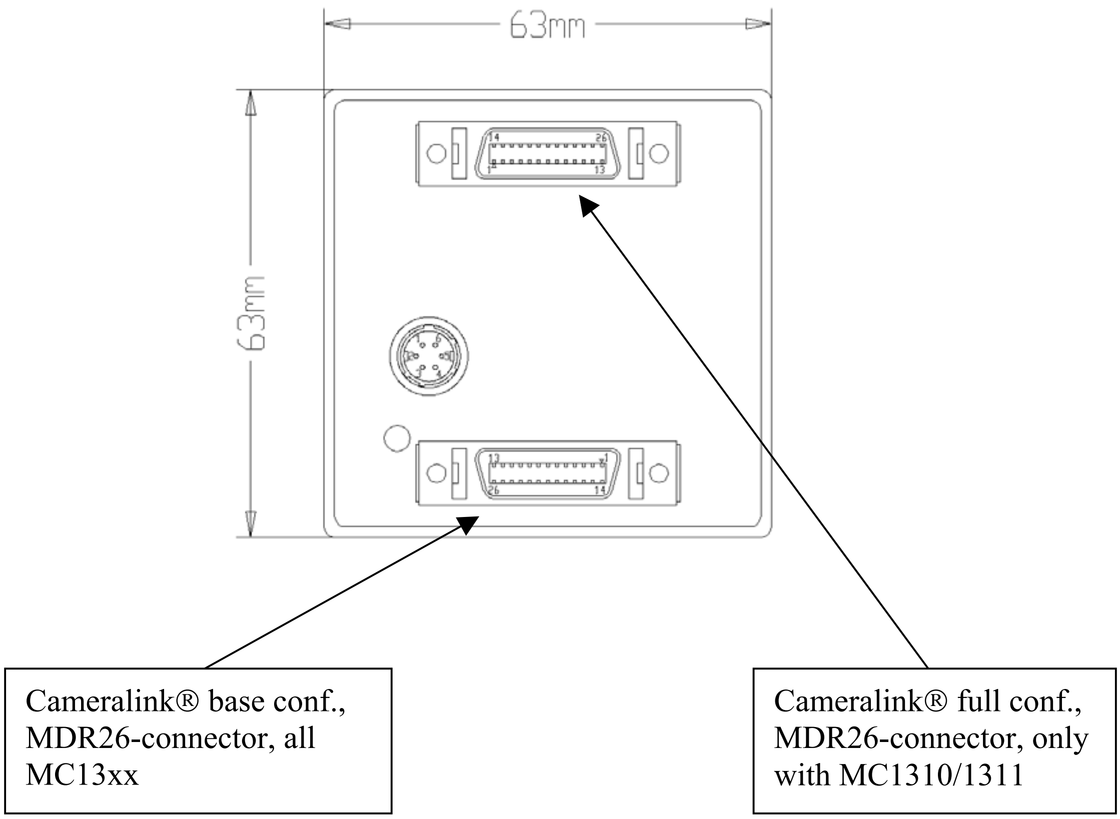
8.1.1 Dimensioned drawing, side view of MC13xx



8.1.2 Dimensioned drawing, front view of MC13xx



8.1.3 Dimensioned drawing, rear view of MC13xx



8.2 Lens adjustment

8.2.1 Adjustable lens adapter

For fine adjustment of the focal length a lens adapter with an adjustment range of ± 1 mm is provided. Use the three screws nearby the sensor window to fasten the lens adapter after a proper adjustment together with the chosen lens.

8.2.2 Lens selection

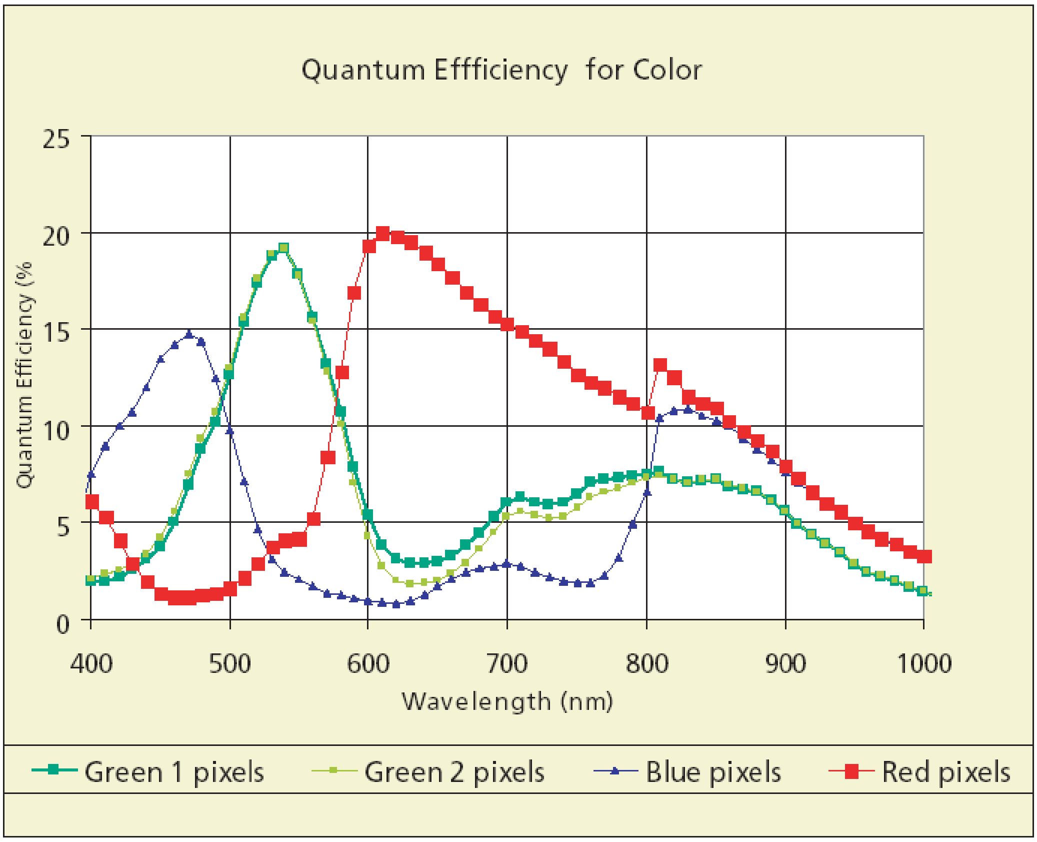
Due to the size of the sensor use C-Mount lenses with the largest possible optical diameter or an adapter for lenses like F-Mount, especially for lenses with a focal length < 25mm..

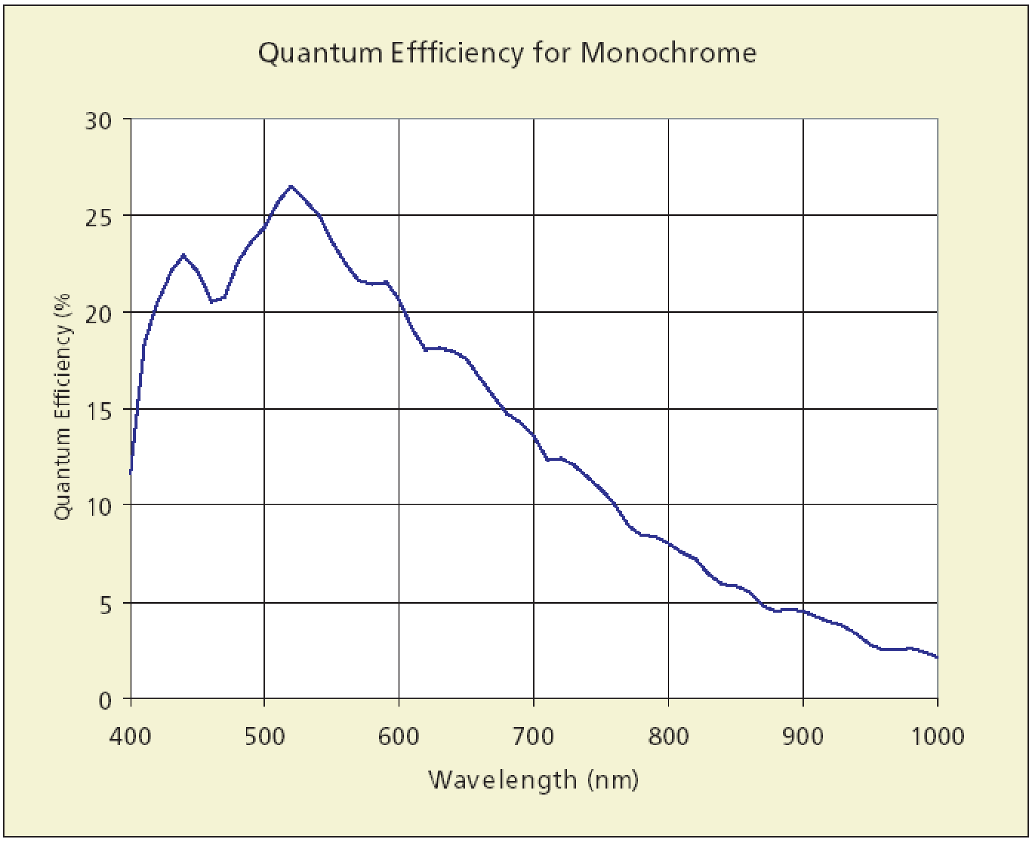
9 Technical Data

MC1302, MC1310 MC1303, MC1311	Monochrome Bayer Filter
Number of pixel	1280 x 1024
Pixel size	12 x 12 µm
Active area	15,36 (H) x 12,29 (V) mm
Fill factor	40%
Sensitivity at 550 nm @ Vref = 1V (a2 = 66h)	1600LSB/lux-sec
Spectral response	400..800nm
Shutter	Electronic „Freeze Frame“ Shutter
Trigger	Asynchronous shutter, shutter time selectable with internal timer or by pulse width of trigger signal
Internal Dynamic	59 dB
Power supply	8 ... 35 V
Power consumption	max. 6 W
Serial data link	RS-644 with Camera Link® 9600 – 115 KBd, 8 bits, 1 stop bit, no parity, no handshake
Digital video MC1310, MC1311 MC1302, MC1303	 Camera Link®, Base or Full configuration Camera Link®, Base configuration
Lens mount	C-mount, 1“
Dimensions (WxHxD in mm)	63 x 63 x 41
Temperature range	+5 ... +50° C
Weight	ca. 300 g

Table 8.2-1

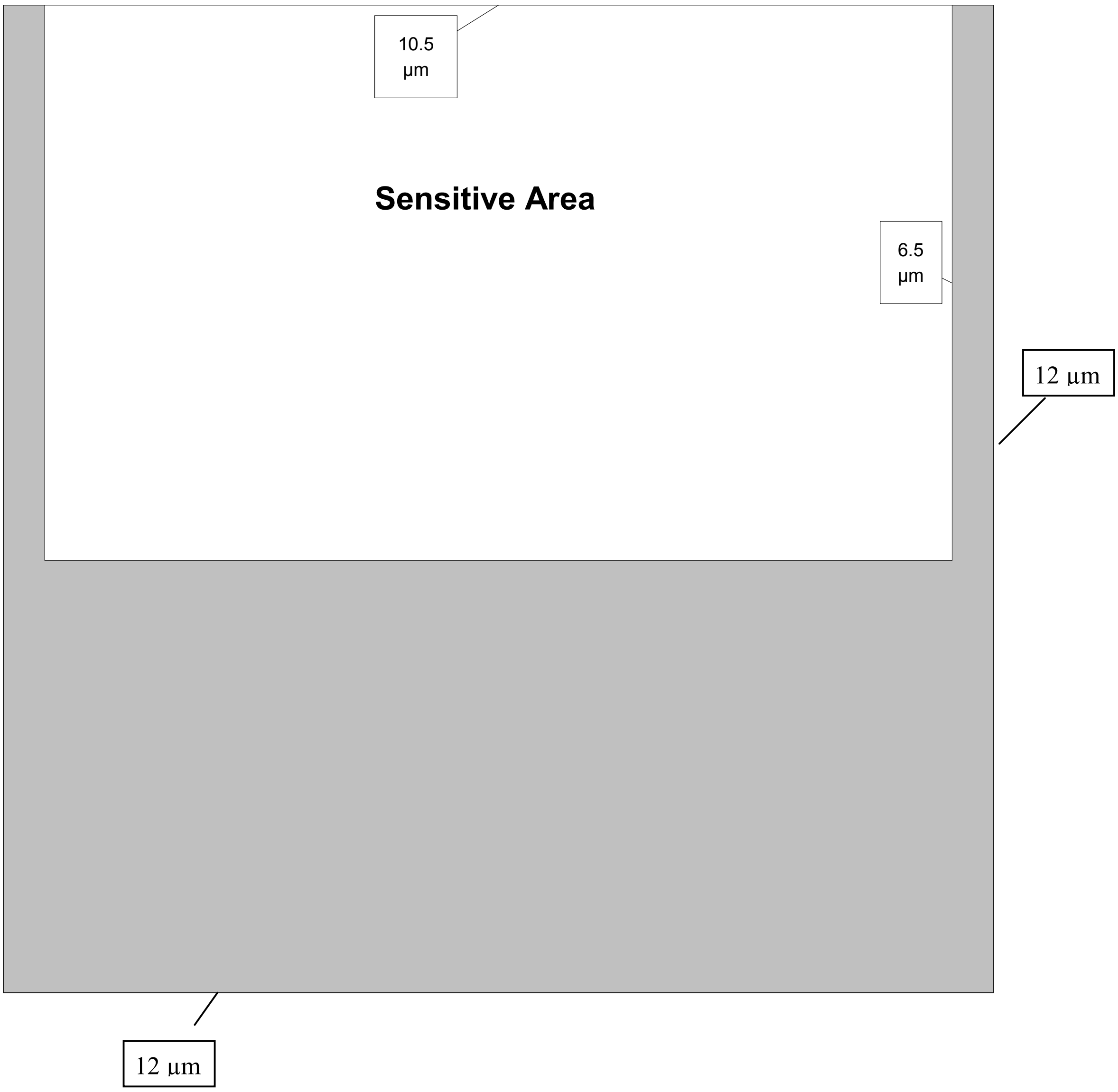
9.1 Spectral response





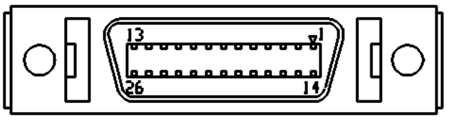
9.2 Sensitive area of a pixel

Pixel size:	12 x 12 µm
Fill factor:	40 %
Sensitive area:	10,5 x 6,5 µm



9.3 Connector pinning

9.3.1 Camera Link® Connector, MDR-26



„Base Camera Link® " Pinning:

pin	signal	pin	signal
1	GND	14	GND
2	X0-	15	X0+
3	X1-	16	X1+
4	X2-	17	X2+
5	XCLK-	18	XCLK+
6	X3-	19	X3+
7	SERTC+	20	SERTC-
8	SERTFG-	21	SERTFG+
9	CC1-	22	CC1+
10	CC2+	23	CC2-
11	CC3-	24	CC3+
12	CC4+	25	CC4-
13	GND	26	GND

Table 9.3-1

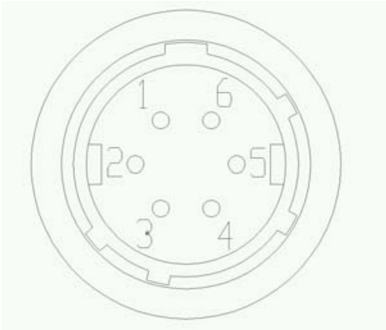
„Full Camera Link® " Pinning (second connector for MC1310/11):

pin	signal	pin	signal
1	GND	14	GND
2	Y0-	15	Y0+
3	Y1-	16	Y1+
4	Y2-	17	Y2+
5	YCLK-	18	YCLK+
6	Y3-	19	Y3+
7	100 Ω Term.	20	100 Ω Term
8	Z0-	21	Z0+
9	Z1-	22	Z1+
10	Z2+	23	Z2-
11	ZCLK-	24	ZCLK+
12	Z3+	25	Z3-
13	GND	26	GND

Table 9.3-2

manufacturer: 3M
Order-Nr. 10226-6212VC

9.3.2 Circular power connector, 6-pin



pin	signal	pin	signal
1	VCC	4	DGND*
2	VCC	5	GND
3	STRB	6	GND

Table 9.3-3

*DGND ... digital GND for signal STRB

Manufacturer: Hirose
Order no.: HR10A-7P-6S

9.4 Camera Link® Bit Assignments

9.4.1 Base Camera Link® 2*8/10 - Bit Assignment

The following table shows the bit assignment of two adjacent pixel, eigth or ten bits each. All unused bits are set to logical LOW level, the SPARE outputs are set to logical HIGH level.

Plug 1, Camera Link X, 2*8-Bit			Plug 1, Camera Link X, 2*10-Bit		
Port	Tx	Signal	Port	Tx	Signal
A0	0	D0	A0	0	D0
A1	1	D1	A1	1	D1
A2	2	D2	A2	2	D2
A3	3	D3	A3	3	D3
A4	4	D4	A4	4	D4
A5	6	D5	A5	6	D5
A6	27	D6	A6	27	D6
A7	5	D7 (msb)	A7	5	D7
B0	7	D8	A8	7	D8
B1	8	D9	A9	8	D9 (msb)
B2	9	D10	LOW	9	LOW
B3	12	D11	LOW	12	LOW
B4	13	D12	B8	13	D18
B5	14	D13	B9	14	D19 (msb)
B6	10	D14	LOW	10	LOW
B7	11	D15 (msb)	LOW	11	LOW
LOW	15	LOW	B0	15	D10
LOW	18	LOW	B1	18	D11
LOW	19	LOW	B2	19	D12
LOW	20	LOW	B3	20	D13
LOW	21	LOW	B4	21	D14
LOW	22	LOW	B5	22	D15
LOW	16	LOW	B6	16	D16
LOW	17	LOW	B7	17	D17
LVAL	24	LVAL	LVAL	24	LVAL
FVAL	25	FVAL	FVAL	25	FVAL
DVAL	26	DVAL	DVAL	26	DVAL
SPARE	23	HIGH	SPARE	23	HIGH
TxClk			TxClk		

Table 9.4-1

9.4.2 Full Camera Link® 8*8-Bit Assignment

The following table shows the bit assignment of eight adjacent pixel. All unused bits are set to logical LOW level, the SPARE outputs are set to logical HIGH level.

Plug 1, Camera Link® X			Plug 2, Camera Link® Y			Plug 2, Camera Link® Z		
Port	Tx	Signal	Port	Tx	Signal	Port	Tx	Signal
A0	0	D0	D0	0	D24	G0	0	D48
A1	1	D1	D1	1	D25	G1	1	D49
A2	2	D2	D2	2	D26	G2	2	D50
A3	3	D3	D3	3	D27	G3	3	D51
A4	4	D4	D4	4	D28	G4	4	D52
A5	6	D5	D5	6	D29	G5	6	D53
A6	27	D6	D6	27	D30	G6	27	D54
A7	5	D7 (msb)	D7	5	D31 (msb)	G7	5	D55 (msb)
B0	7	D8	E0	7	D32	H0	7	D56
B1	8	D9	E1	8	D33	H1	8	D57
B2	9	D10	E2	9	D34	H2	9	D58
B3	12	D11	E3	12	D35	H3	12	D59
B4	13	D12	E4	13	D36	H4	13	D60
B5	14	D13	E5	14	D37	H5	14	D61
B6	10	D14	E6	10	D38	H6	10	D62
B7	11	D15 (msb)	E7	11	D39 (msb)	H7	11	D63 (msb)
C0	15	D16	F0	15	D40	LOW	15	LOW
C1	18	D17	F1	18	D41	LOW	18	LOW
C2	19	D18	F2	19	D42	LOW	19	LOW
C3	20	D19	F3	20	D43	LOW	20	LOW
C4	21	D20	F4	21	D44	LOW	21	LOW
C5	22	D21	F5	22	D45	LOW	22	LOW
C6	16	D22	F6		D46	LOW	16	LOW
C7	17	D23 (msb)	F7	17	D47 (msb)	LOW	17	LOW
LVAL	24	LVAL	LVAL	24	LVAL	LVAL	24	LVAL
FVAL	25	FVAL	FVAL	25	FVAL	FVAL	25	FVAL
DVAL	26	DVAL	DVAL	26	DVAL	DVAL	26	DVAL
SPARE	23	HIGH	SPARE	23	HIGH	SPARE	23	HIGH
TxClk			TxClk			TxClk		

Table 9.4-2

9.4.3 10*8-Bit Assignment

The below table shows the the assignment of 10 adjacent pixel, 8-Bit each. This assignment is compatible to Baslers A504 camera.

Plug 1, Camera Link® X			Plug 2, Camera Link® Y			Plug 2, Camera Link® Z		
Port	Tx	Signal	Port	Tx	Signal	Port	Tx	Signal
A1	0	D0_0	D3	0	D3_2	G6	0	D6_5
A2	1	D0_1	D4	1	D3_3	G7	1	D6_6
A3	2	D0_2	D5	2	D3_4	G8	2	D6_7 (msb)
A4	3	D0_3	D6	3	D3_5	H1	3	D7_0
A5	4	D0_4	D7	4	D3_6	H2	4	D7_1
A6	5	D0_5	D8	5	D3_7 (msb)	H3	5	D7_2
A7	6	D0_6	E1	6	D4_0	H4	6	D7_3
A8	7	D0_7 (msb)	E2	7	D4_1	H5	7	D7_4
B1	8	D1_0	E3	8	D4_2	H6	8	D7_5
B2	9	D1_1	E4	9	D4_3	H7	9	D7_6
B3	10	D1_2	E5	10	D4_4	H8	10	D7_7 (msb)
B4	11	D1_3	E6	11	D4_5	I1	11	D8_0
B5	12	D1_4	E7	12	D4_6	I2	12	D8_1
B6	13	D1_5	E8	13	D4_7 (msb)	I3	13	D8_2
B7	14	D1_6	F1	14	D5_0	I4	14	D8_3
B8	15	D1_7 (msb)	F2	15	D5_1	I5	15	D8_4
C1	16	D2_0	F3	16	D5_2	I6	16	D8_5
C2	17	D2_1	F4	17	D5_3	I7	17	D8_6
C3	18	D2_2	F5	18	D5_4	I8	18	D8_7 (msb)
C4	19	D2_3	F6	19	D5_5	J1	19	D9_0
C5	20	D2_4	F7	20	D5_6	J2	20	D9_1
C6	21	D2_5	F8	21	D5_7 (msb)	J3	21	D9_2
C7	22	D2_6	G1	22	D6_0	J4	22	D9_3
C8	23	D2_7 (msb)	G2	23	D6_1	J5	23	D9_4
LVAL	24	LVAL	G3	24	D6_2	J6	24	D9_5
FVAL	25	FVAL	G4	25	D6_3	J7	25	D9_6
D1	26	D3_0	G5	26	D6_4	J8	26	D9_7 (msb)
D2	27	D3_1	LVAL	27	LVAL	LVAL	27	LVAL
TxClk			TxClk			TxClk		

Table 9.4-3

9.5 Frequency selection

Depending on the selected line length and the datarate on the “Camera Link®” interface the frequency selection table can provide an optimal ratio of sensor /pixel clock. The pixel clock is only dependent on the selected step and not on the linelength.

The sensor clock is dependent on both the selected step, the line length and the data width. The tables show the selectable frequencies and the correponding codes to program the synthesizer accordingly.

9.5.1 Frequencies for video data width 2*8/10 - Bit, Base Camera Link®

9.5.1.1 Linelength <= 100 Pixel

clock / step	pixel clock in MHz	Sensorclock (MHz) for linelength <= 100 Pixel	Framerate (fps) for resolution: 100 x 100 Pixel
0	7,5	18,4	1352,9
1	10,0	24,5	1801,5
2	12,5	30,6	2250,0
3	15,0	36,9	2713,2
4	17,5	42,9	3154,4
5	20,0	49,0	3602,9
6	22,5	55,1	4051,5
7	25,0	61,2	4500,0
8	26,9	65,8	4838,2
9	27,5	67,4	4955,9
10	30,0	67,4	4955,9
11	33,0	67,4	4955,9
12	35,0	67,4	4955,9
13	40,0	67,4	4955,9
14	50,0	67,4	4955,9
15	60,0	67,4	4955,9

Table 9.5-1

9.5.1.2 Linelength <= 240 Pixel

Frequencies / Step	Pixelclock (MHz)	Sensorclock (MHz) for linelength <= 240 Pixel	Framerate (fps) for resolution: 240 x 240 Pixel
0	7,5	7,1	217,5
1	10,0	9,5	291,1
2	12,5	11,9	364,6
3	15,0	14,3	438,1
4	17,5	16,7	511,6
5	20,0	19,1	585,2
6	22,5	21,4	655,6
7	25,0	23,8	729,2
8	26,9	25,6	784,3
9	27,5	26,2	802,7
10	30,0	28,6	876,2
11	33,0	31,2	955,9
12	35,0	33,4	1023,3
13	40,0	38,1	1167,3
14	50,0	47,6	1458,3
15	60,0	57,1	1749,4

Table 9.5-2

9.5.1.3 Linelength <= 640 Pixel

Frequencies / Step	Pixelclock (MHz)	Sensorclock (MHz) for linelength <= 640 Pixel	Framerate (fps) for resolution: 640 x 480 Pixel
0	7,5	3,1	47,4
1	10,0	4,1	62,7
2	12,5	5,1	78,0
3	15,0	6,1	93,2
4	17,5	7,1	108,5
5	20,0	8,2	125,4
6	22,5	9,1	139,1
7	25,0	10,2	155,9
8	26,9	11,0	168,2
9	27,5	11,2	171,2
10	30,0	12,2	186,5
11	33,0	13,4	204,8
12	35,0	14,3	218,6
13	40,0	16,3	249,2
14	50,0	20,4	311,9
15	60,0	24,5	374,5

Table 9.5-3

9.5.1.4 Linelength <= 1280 Pixel

Frequencies / Step	Pixelclock (MHz)	Sensorclock (MHz) for linelength <= 1280 Pixel	Framerate (fps) for resolution: 1280 x 1024 Pixel
0	7,5	1,5	10,8
1	10,0	2,0	14,3
2	12,5	2,5	17,9
3	15,0	3,0	21,5
4	17,5	3,5	25,1
5	20,0	4,0	28,7
6	22,5	4,5	32,3
7	25,0	5,1	36,6
8	26,9	5,4	38,7
9	27,5	5,6	40,2
10	30,0	6,1	43,8
11	33,0	6,6	47,3
12	35,0	7,1	50,9
13	40,0	8,1	58,1
14	50,0	10,1	72,5
15	60,0	12,1	86,8

Table 9.5-4

Tolerance: ± 5 %

9.5.1.5 Respective codes for the clock synthesizer

Each frequency pair corresponds to two hexadecimal codes that are used to program the synthesizer. These are also obtained on a read Camera Profile (:w) command.

Codes / Step	Pixel co-des in MHz	Sensor codes (MHz) for: 10 < Line-length <= 100 Pixel	Sensor codes (MHz) for: 100 < Line length <= 240 Pixel	Sensor codes (MHz) for: 240 < Line length <= 640 Pixel	Sensor codes (MHz) for: 640 < Line length <= 1280 Pixel
0	61dd8d	406d01	407182	416a85	416705
1	612585	416905	407181	40ee05	41be8b
2	61dd87	414088	41f988	41de09	407a81
3	61dd0d	406c81	407102	416a05	416685
4	608d02	41f489	41f10c	407182	405201
5	612505	416885	407101	40ed85	413207
6	60e903	41f00f	416906	41f98b	410a05
7	61dd07	414008	41f908	41dd89	407a01
8	611888	41e80c	41e890	41d188	40e203
9	61788b	40f405	40f487	411984	41da08
a	61dc8d	--	407082	416985	416605
b	61e88c	--	407c82	40c105	41898c
c	608c82	--	41f08c	407102	405181
d	612485	--	407081	40ed05	413187
e	61dc87	--	41f888	41dd09	41d589
f	61dc0d	--	407002	416905	416585

Table 9.5-5

There is a 3-byte code for each frequency. The code for the sensor clock is set to sb1…3 of a returned PowerUpProfile (command :w).
The code of the pixel frequency corresponds to sa1…3.

Example: return of frequency codes
On command :w following answer was returned:
6d774ac800006a1c**61788b41da08**0003ff3ff000**07f**0300000000000000000000000000000↵

61788b... Sa1...3, pixel clock (see code of table 20)
61788b = step 9, equivalent to 27,5 MHz
41da08... Sb1...3, sensor clock
according to table 20, mode 3
41da08= step9, equivalent to 5,6 MHz
07f.. Line length 1280 pixel

9.5.2 Frequencies for video data width 8*8 - Bit, Full Camera Link®

clock step	pixel clock in MHz	Pixelclock programcode	sensor clock in MHz	Sensorclock programcode	Framerate fps
0	19,5	:S61f10a	15,0	:S41dd0d	107,6
1	24,33	:S60fd03	18,7	:S40e904	134,14
2	29,24	:S61d08d	22,5	:S40e903	161,4
3	34,40	:S606481	26,5	:S41c08e	190,1
4	39,01	:S61f08a	30,0	:S41dc8d	215,2
5	43,82	:S61a087	33,7	:S41d08b	241,75
6	48,74	:S61d087	37,5	:S40e884	269
7	53,57	:S61a80d	41,2	:S41e089	295,5
8	58,49	:S61d00d	45,0	:S40e883	322,81
9	63,28	:S61900a	48,7	:S40fc83	349,3
10	68,19	:S608802	52,5	:S41d80f	376,61
11	70,77	:S60b403	54,4	:S40e006	390,24
12	73,05	:S61a809	56,2	:S40e806	403,15
13	75,73	:S61b809	58,2	:S411007	417,5
14	78,02	:S61f00a	60,0	:S41dc0d	430,41
15	81,1	:S607801	62,3	:S412407	446,9

Table 9.5-6

9.5.3 Frequencies for video data width 10*8 – Bit

Use the arbitrary frequency selection command:

command **:S <x_0>**

<x_0> 6 characters, programcode in the following table

clock step	pixel clock in MHz	Pixelclock programcode	sensor clock in MHz	Sensorclock programcode	Framerate fps
0	15,75	:S616d09	15,0	:S41dd0d	107,6
1	19,72	:S61a108	18,7	:S40e904	134,14
2	23,65	:S612904	22,5	:S40e903	161,4
3	27,81	:S614089	26,5	:S41c08e	190,1
4	31,5	:S616c89	30,0	:S41dc8d	215,2
5	35,38	:S60b483	33,7	:S41d08b	241,75
6	39,32	:S607481	37,5	:S40e884	269
7	43,23	:S61f889	41,2	:S41e089	295,5
8	47,30	:S612884	45,0	:S40e883	322,81
9	51,08	:S61780c	48,7	:S40fc83	349,3
10	54,83	:S61d00e	52,5	:S41d80f	376,61
11	57,14	:S607002	54,4	:S40e006	390,24
12	58,98	:S605401	56,2	:S40e806	403,15
13	61,09	:S60dc05	58,2	:S411007	417,5
14	63,0	:S616c09	60,0	:S41dc0d	430,41
15	65,43	:S611006	62,3	:S412407	446,9

Table 9.5-7

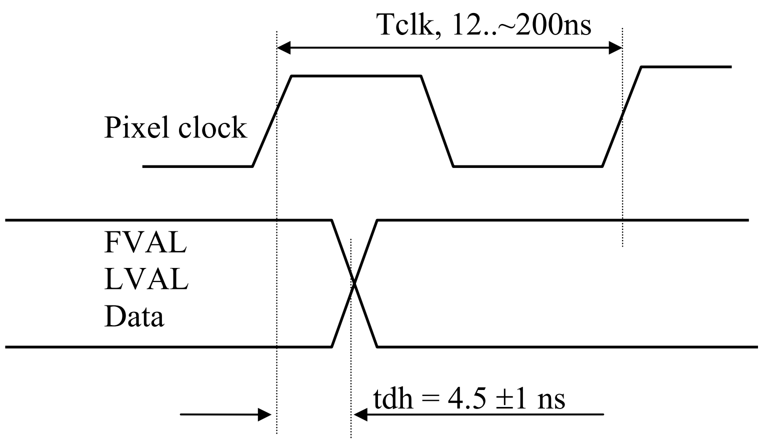
9.6 Programming sequence, factory profile f3

Example:	resolution:	1.280 x 1.024 pixel
	frame rate:	47 fps
	pixel clock:	33 MHz sensor clock: 6,65 MHz
	shutter:	full frame , exposure time: 21 ms

Strings:	:a16d	
	:a277	
	:a34a	
	:a4c8	
	:a5xx	xx... may be any value 00h ... ffh
	:a600	
	:a76a	
	:a81c	
	:r6000	
	:r1000	
	:r23ff	
	:r33ff	
	:r4000	
	:r507f	
	:r7000	
	:r6030	
	:r8000	
	:r9000	
	:ra000	
	:rb000	
	:rc000	
	:rd000	
	:re000	
	:rf000	
	:sb	

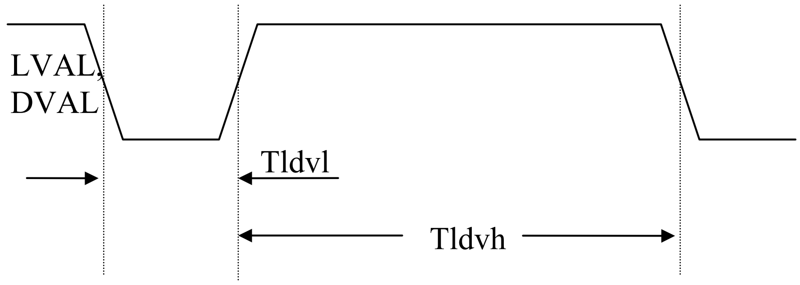
9.7 Timing

9.7.1 Pixel clock



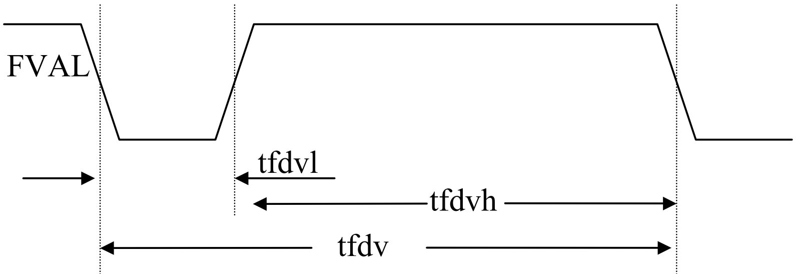
The above illustration shows hold time of video data, LVAL and FVAL signal to rising edge of pixel clock.

9.7.2 Line Valid (LVAL, DVAL)



LVAL and DVAL are connected internally in the camera. The timing for the LVAL / DVAL signal shown in multiples of the pixel clock depend on the ratio of sensor/pixel clock, on selected line length, and on video data width. Tldvh is always the same for a specific setting of the above parameters, Tldvl my vary by one clock from line to line. The LVAL / DVAL signal is also output while FVAL is inactive.

9.7.3 Frame Valid (FVAL)



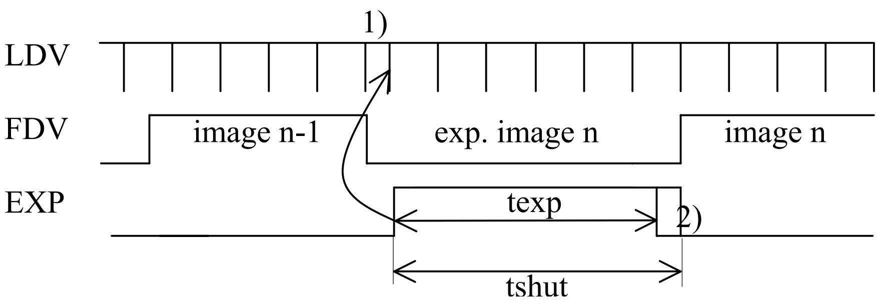
The rising edge of FVAL marks that line, that is programmed in Register r1.

Tfdvh is equal to the value programmed in Register r3 multiplied with time/line. Tfdvl in synchronous mode is equal to one time/line.

9.7.4 Exposure Signal (EXP)

The EXP signal is positive active if register 7, Bit 8 = 0, negativ active if register 7, Bit 8 = 1. EXP Signal may not be asserted while the previous image is output (FDV active)

The sensors exposure starts and the strobe output activates (texp, (1) three sensor clocks after the active edge of the EXP signal (tshut), and ends up to 135 sensor clocks after deactivation (2).



1) The active edge of the EXP signal clears the horizontal counter.

2) End of exposure time is synchronised with the internal horizontal counter.

EXP is also used as enable signal for ImageBLITZ shutter release.